AN INNOVATIVE APPROACH TOWARD GAIT FEATURE DETECTION IN CHILDREN WITH CP

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INTRODUCTION and AIM

Classifying gait patterns in children with cerebral palsy (CP) and reducing the vast amount of data from gait analysis into a set of clinically relevant gait features remains a challenge [1]. A priori selection of gait features, often based on clinical expert knowledge, can result in either incomplete or redundant data [2]. The goal is to quantify differences in lower limb kinematics between CP children and typically developing controls using principal component analysis (PCA). Secondly, for features that differ between CP and controls, a discriminant analysis (DA) will be applied to determine which features discriminate best between both groups.

PATIENTS/MATERIALS and METHODS

100 CP gait trials and 72 age-matched control trials were retrospectively selected from the database of University Hospital Leuven. Children with spastic diplegia or hemiplegia (GMFCS level I-III), aged 5 to 12 years, without previous lower limb surgery and/or lower limb botulinum toxin treatment within 6 months prior to gait analysis were included. Pelvis, hip, knee and ankle joint kinematics were calculated from 3D gait analysis. PCA was applied to continuous waveform data using custom made MATLAB© software (Mathworks, USA). The number of principal components (PCs) explaining 90% of the variability were retained. PC scores were calculated for each trial and analyzed for group differences using unpaired t-tests. Subsequently, DA was performed using the PCs that were significantly different between groups, following the approach of Deluzio et al. [3, 4]. This method allows us to detect the three most discriminative features between groups.

RESULTS

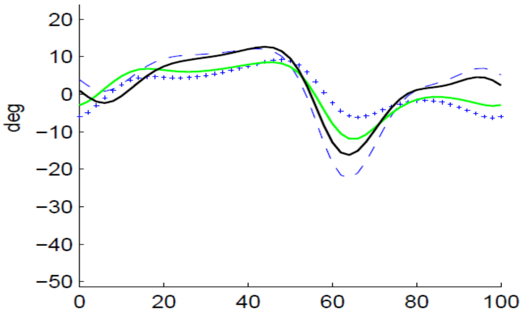

Figure 1. Mean ankle movement of CP (green) and controls (black) during one stride (0-100%). 5th (---) and 95th (+++) percentile of PC2 scores of the ankle movement show that PC2 captures the peak plantar flexion during push-off.

Table 1. Description of principal components from lower limb joints in the sagittal plane. Mean (SD) PC scores and p-values are listed.

PC		CP (n=100)	Control (n=72)	p-value
Pelvis	PC1	-20.24 (37.94)	28.12 (30.84)	**<0.0001***
Hip	PC1	-20.93 (47.89)	29.07 (32.8)	**<0.0001***
	PC2	0.2 (22.11)	-0.27 (15.99)	0.8778
	PC3	-0.09 (19.38)	0.13 (12.16)	0.933
Knee	PC1	-18.87 (49.13)	26.21 (37.5)	**<0.0001***
	PC2	-14.1 (32.47)	19.59 (23.51)	**<0.0001***
	PC3	-2.13 (29.58)	2.96 (19.57)	0.2046
	PC4	3.22 (20.04)	-4.47 (13.07)	**0.005***
Ankle	PC1	3.68 (54.9)	-5.11 (28.28)	0.2153
	PC2	8.57 (14.14)	-11.9 (13.13)	**0.0001***
	PC3	-5.04 (12.86)	7.0 (12.43)	**0.0001***
	PC4	3.14 (14.66)	-4.36 (10.37)	**0.0003***

*significant difference between CP and control, based on unpaired t-test (α=.05)

Only 4 PCs were not able to highlight differences between groups. The remaining 8 PCs were implemented in the discriminant analysis. The cross-validation results showed that 91.3% of all trials can be classified correctly and the coefficient of the PCs in the discriminant function were highest for the ankle-PC2 (0.71), the pelvis-PC1 (0.67) and the hip-PC (0.6).

DISCUSSION and CONCLUSIONS

Based on the PCA and linear DA, three PCs were defined as being the most important to discriminate between CP children and controls. PC2 in the ankle mainly represents plantar flexion motion during push-off, PC1 in the pelvis and in the hip both point towards an offset, i.e. a higher mean anterior tilt and higher hip flexion angle throughout a gait cycle for the CP group. This approach toward gait classification is relatively new in CP. Only one article has previously applied this method and found no significant differences in the sagittal plane between children classified as GMFCS level I and II [4]. In future research this method will be extended to larger sample sizes, across the three different planes and for various subgroups of children with CP.

REFERENCES

[1] Dobson F et al. Gait Posture 25, 140–52 (2007). [2] Mantovani G et al. J Biomech 45, 2109-15 (2012). [3] Deluzio KJ et al. Gait Posture 25, 86-93 (2007). [4] Kirkwood RN et al. ISRN pediatrics 2012, 1630-39 (2012).